AN UNFOCUSED SAR APPROACH TO IMPROVE AZIMUTH RESOLUTION OF DUAL-FREQUENCY POLARIZED SCATTEROMETER(DFPSCAT)

Gang Wang[1,2] *, Xiaolong Dong*[1] *,Qingliu Bao*[1,2]*, Di Zhu*[1]*, Xingou Xu*[1]

1. CAS Key Laboratory of Microwave Remote Sensing, National Space Science Center, Chinese Academy of Sciences, Beijing, 100190, China
2. University of Chinese Academy of Sciences, Beijing, 100049, China.
Email: wangganggreat@163.com

1. ABSTRACT

For the spaceborne scanning pencil-beam scatterometer, the azimuth resolution is low that could not meet the demands. Based on the motion of platform and the scanning rules of the spaceborne scatterometer, this paper takes an unfocused SAR approach to improve the Azimuth Resolution.

Index Terms— scatterometer, unfocused SAR, Doppler, azimuth resolution

2. INTRODUCTION

WCOM(Water Cycle Observation Mission) proposes a X-Ku band dual-frequency polarized SCATterometer(DFPSCAT) with relative high resolution and a 1000km swath for mapping of snow water equivalent and freeze-thaw processes [1].The retrieval of snow water equivalent is very complicated, especially on snow mountains the retrieval error is very high when the resolution is above 10km, so the resolution is required to be 2~5km [2]. The spaceborne scanning pencil-beam scatterometer can provide high SNR, but shorter dwell time and it does have the advantage of covering a larger cover area than SAR.As with all scatterometers. DFPSCAT will use Pulse compression by linear frequency modulation along the elevation direction, which provides range resolution of about 50m(B=5MHz) and 25m(B=10MHz).Given that the requirement of resolution is 2~5km,the area could theoretically be resolved into as many as $2000 \div 50=40$ or $5000 \div 50=100$ separate elements, each constituting one independent samples, and corresponding to a normalized-measurement standard deviation of $1/\sqrt{40}$ and 1/10 [3]. To achieve an improved resolution along the azimuth direction, the system will use an unfocused synthetic aperture technique where the Doppler effect is exploited to synthesize a longer aperture, as well as super-resolution reconstruction by oversampling in the direction of the azimuth.

3. SYSTEM PARAMETERS

In order to have both high accuracy measurement of backscattering coefficient and relative high resolution of the snow water equivalent measurement, the system parameters should be a compromise between the two variables for the system design of DFPSCAT.

The unfocused SAR method should not be used when the azimuth is less than 35 degree, which some other methods will be used, such as resolution reconstruction. At the far swath, the footprint of azimuth corresponds to a Doppler bandwidth of approximately 20kHz,while at near swath this corresponds to a Doppler bandwidth of about 10kHz,and thus requires a minimum 20kHz PRF in order to unambiguously resolve the scene in azimuth[4]. To acquire high resolution in azimuth direction, the rotation rate should be designed small, and meanwhile satisfies the no gap coverage of the footprint. Some key specifications are shown in Table 1.

frequency	**9.6, 14/17GHz**
bandwidth	**5MHz/10MHz**
peak power	**400W**
polarization	**HH, VV, HV/VH**
antenna dimension	**1.5m×0.3m**
raw resolution	**50m(elevation)×15km(azimuth)**
resolution after processing	**2~5km**

Table 1 system parameters

4. BASIC PRINCIPLE

According to the echo signal property of the target, the secondary phase item of Taylor series for the echo equation can be used to ensure coherent accumulation without correction.

When the secondary phase item is no more than , the coherent accumulation time should satisfy:

$$T_s \le \frac{1}{V_{sat}} \sqrt{\lambda R_0 / (1 - \cos^2_{\gamma} \sin^2_{\varphi})}$$

Where φ is angle between satellite nadir point and antenna direction and γ is azimuth. When the error of phase center is small enough that the targets do not have migration through resolution cell, thus

$$T_s < \frac{c}{2BV_{sat} \cos\gamma_0 \sin\varphi}$$

A general goal in this method is to make sure the numbers of the beam sharpening ratio are stable, which we can have two methods:1)change PRF according to the azimuth but the numbers of accumulation pulse are stable; 2)change the numbers of accumulation pulse according to the azimuth, but the PRF is stable.

Considering the engineering realization, we usually use the second method, which uses constant PRF and rotation rate, to change the numbers of the accumulation pulse according to the azimuth. The numbers of the accumulation pulse can be approximately equal to the numbers of the echoes from one beam width, while each target radial velocity relative to the radar is different, so each echo of the beam may have the frequency difference of arrival. A set of narrow-band filters, whose center frequencies correspond to the echo's, can accomplish the division of Doppler frequency. The specific choice of filter bandwidths is based in system parameters and resolution acquirements. The key factors that affect unfocused synthetic aperture method:

1)system parameters;

2) Doppler Centroid Estimation;

3)phase center;

4)constant sharpening ratio in different azimuth.

The quality of unfocused SAR approach is associated with the accuracy of Doppler centroid estimation, which can influence the target location and change the Doppler centroid frequency. DFPSCAT can not only measure the HH/VV and HV/VH, but also can measure the phase information, thus the center of phase is very important.

5. SIMULATION

According to the requirements of the beam sharpening ratio, we simulate the relationship between the beam sharpening ratio and azimuth in different PRF, see Figure 1. The beam sharpening ratio will get larger with the PRF arise, so the PRF should be large enough. The choice of the coherent accumulation time is shown in Figure2 under condition that the coherent accumulation time is allowed when the band width is 5MHz.

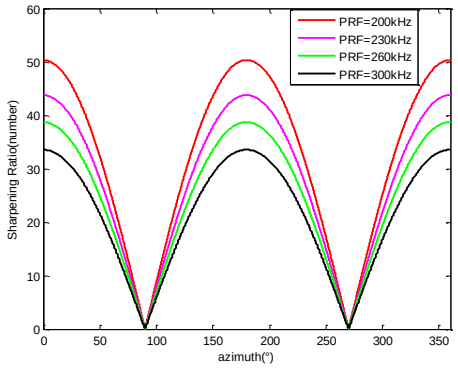

Figure 1.Sharpening ratio with the azimuth

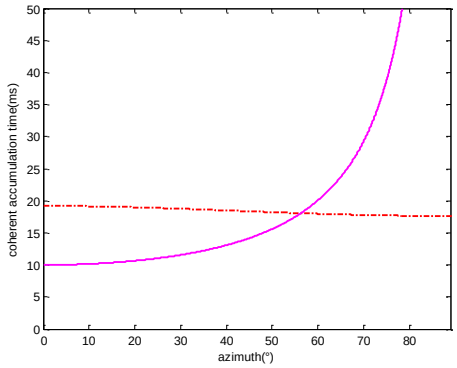

Figure 2. The limitation of the coherent accumulation time

As discussed at above, the antenna rotation rate of 4 rpm combined with PRF of 300Hz, produces approximate 4500 pulses during one circle. The numbers of coherent accumulation pulse are four, see Figure 3, with the requirements to satisfy 2~5 km resolution after processing.

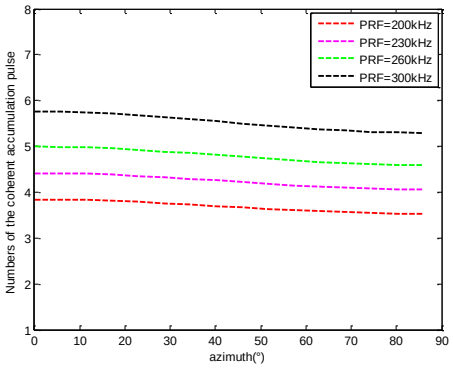

Figure 3.The numbers of coherent accumulation pulse

6. CONCLUSION

An unfocused SAR processing method is introduced in this paper, which can acquire azimuth resolution enhancement without using SAR technology. Through the simulation, it was demonstrated that this approach can be used on the engineering and improve the azimuth resolution.

7. REFERENCES

[1] Dong X, Liu H, Wang Z, et al. WCOM: The mission concept and payloads of a global water cycle observation mission[C]. Geoscience and Remote Sensing Symposium (IGARSS), 2014 IEEE International. IEEE, 2014:3338 - 3341.

[2] Shi J. Snow Water Equivalence Retrieval Using X and Ku band Dual-Polarization Radar[C]. Geoscience and Remote Sensing Symposium, IGARSS, IEEE International Conference on. IEEE, 2006:2183 - 2185.

[3]M W Spencer, C Wu, D G Long, et al. Improved Resolution Backscatter Measurements with the SeaWinds Pencil-Beam Scatterometer [J]. IEEE Transactions on Geoscience and Remote Sensing, 2000, 38(1):89-104.

[4] D G Long, C-Y Chi and F K Li. The Design of an Onboard Digital Doppler Processor for a Spaceborne Scatterometer [J]. IEEE Transactions on Geoscience and Remote Sensing, 1988, 26(6): 869-878.